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(54) Abstract Title
Sliding member with Cu, Ag and resin layers

(57) A multi-layer sliding member has a backing metal 1, a Cu alloy layer 2 on the backing metal 1, an Ag layer 3 on the Cu alloy layer 3 and a resin layer 4 on the Ag layer 3. The Ag layer 3 is 3-50μm thick and the resin layer 4 is 2-20μm thick. The resin may be a thermoplastic, eg a fluorocarbon polymer (eg PTFE), an allyene sulfide resin (eg PPS), an aromatic polyether ketone resin (eg PEEK), a thermosetting resin (eg an epoxy resin or PAI), a phenolic resin, a polyamide resin, or a mixture of some of the above. Solid lubricants graphite or molybdenum disulphide may be added to the resin. The copper alloy 2 layer may contain Pb, Sn, Mn, Cr, Zn and the like. The Ag layer 3 may be pure Ag, or include Sb, Pd, Cu or Pb. The Ag layer 3 and/or the copper alloy layer 2 may be Pb free. The Cu alloy layer 2 can be sintered onto the backing metal 1 (which may be steel plate), the Ag layer 3 applied by wet electroplating, and the resin layer applied by air spraying.

FIG.1

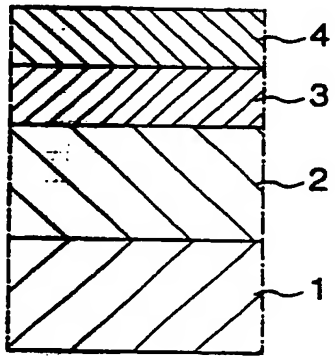

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FIG.1

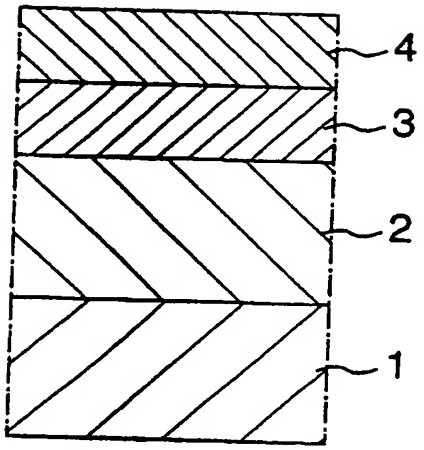


FIG.2

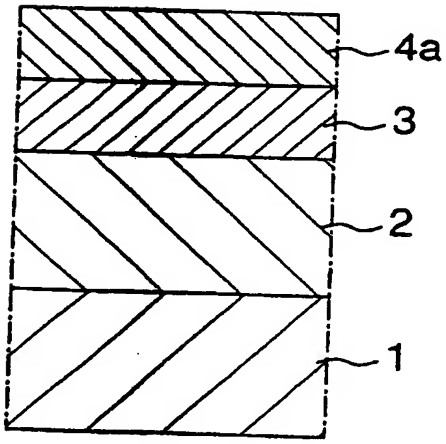
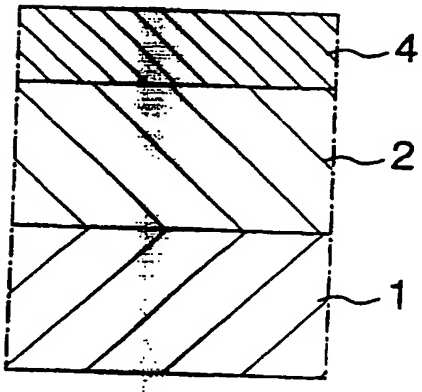


FIG.3



BACKGROUND OF THE INVENTION

This invention relates to a multi-layer sliding member used as a bearing or the like.

Bearings, each having a Cu alloy layer formed on a backing metal thereof, have been extensively used. Particularly, there are known the type of bearings for an internal combustion engine, in which a dam layer of Ni and the like is formed on a Cu alloy layer, and an overlay of a Pb alloy or a Sn alloy is formed on the dam layer. When the temperature of the dam layer becomes high during use, a component (such as Sn and In) of the overlay diffuses into the Cu alloy layer, so that the corrosion resistance and wear resistance of the overlay are lowered. Therefore, the dam layer is provided in order to prevent this diffusion.

However, when the overlay is worn, the hard dam layer is exposed, so that seizure can occur. Therefore, as shown in Fig. 2, there is proposed a sliding member in JP-A-1-316514, filed by the Applicant of the present application, in which a soft silver alloy layer 3, having a thickness of 3 to 50 μm, is formed between a Cu alloy layer 2 and a lead base alloy layer (overlay) 4a which are formed on a backing metal 1. With this construction, Sn and In, contained in the lead base alloy layer 4a, are prevented from diffusing

into the Cu alloy layer 2.

JP-A-9-79262 discloses a sliding bearing which comprises a backing metal 1, a Cu alloy layer 2 formed on the backing metal 1, and a resin layer 4 formed on the Cu alloy layer 2 as shown in Fig. 3, the resin layer 4 comprising 30 to 90 wt.% of a solid lubricant, such as MoS_2, WS_2, h-BN, graphite and the like, and 10 to 70 wt.% of a thermosetting resin such as a polyimide resin, an epoxy resin and a phenolic resin. With this construction, a fatigue resistance and a load capacity can be enhanced.

Recently, with the high-output and high-rotational speed (engine speed) design of internal combustion engines, sliding members such as bearings have been used under severer conditions.

In the sliding member disclosed in JP-A-9-79262, the resin layer 4, composed of the thermosetting resin, is formed directly on the Cu alloy layer 2, and therefore when the Cu alloy layer is exposed as a result of wear of the resin layer 4, there is encountered a problem that an anti-seizure property is abruptly lowered.

And besides, there is an increasing tendency to avoid the use of lead (Pb) from the environmental point of view, and it has now been desired to develop a sliding member containing no lead.

SUMMRY OF THE INVENTION

It is therefore an object of this invention to provide a multi-layer resin sliding member which makes less attack on a mating member, and is excellent in wear resistance, and is excellent particularly in anti-seizure property.

Another object of the invention is to provide a multi-layer sliding member which has an excellent anti-seizure property even if it contains no lead.

According to the feature of the present invention, there is provided a multi-layer sliding member comprising a backing metal, a Cu alloy layer formed on the backing metal, an Ag layer formed on the Cu alloy layer, and a resin layer formed on the Ag layer, the Ag layer having a thickness of 3 to 50 μm, and the resin layer having a thickness of 2 to 20μm.

A conventional Cu base sliding alloy can be used as the Cu alloy layer, and such copper alloy contains not more than 25 wt.% Pb and not more than 10 wt.% Sn, Mn, Cr or Zn and the like. Specifically, examples of such alloys are Cu-23Pb-3.5Sn and Cu-15Pb-3Sn. An example of a Cu alloy layer, containing no Pb, is Cu-6Sn or Cu-11Sn-3Ni. The suitable one is selected among these alloys in accordance with the purpose, such as desired load capacity and wear resistance.

According to another feature of the present invention, except for pure silver, an Ag alloy, containing Sb, Pd, Cu or Pb and the like, can be used

as the Ag layer. For example, when the engine speed of an automobile engine becomes high, the temperature of engine oil can rise to about 180 °C. Therefore, it is important to dissipate frictional heat developing on a surface of a bearing. Ag has a very good thermal conductivity, and therefore can radiate the heat rapidly. If the thickness of the Ag layer is less than 3 μm, the heat-radiating effect is not adequate, and therefore the temperature of the resin layer becomes high, so that the anti-seizure property is lowered. If the thickness of the Ag layer is increased, the heat-radiating property is enhanced. However, Ag is expensive, and the cost of the plating is relatively high, and therefore for economical reasons, this thickness should be not more than 50 μm. Preferably, this thickness is 5 to 20 μm. If 2 to 10 wt.% of Sb, Pd, Cu or Pb is added to Ag, the wear resistance is enhanced.

A suitable known resin for a sliding member can be used as the resin layer according to the purpose. Examples of such resin include a thermoplastic resin, such as a fluorocarbon polymer (e.g. PTFE), an allylene sulfide resin (e.g. PPS) and an aromatic polyether ketone resin (e.g. PEEK), a thermosetting resin, such as an epoxy resin, a phenolic resin and a polyimide resin, and a mixture resin formed by mixing these resins together. Particularly, a thermosetting resin, such as a polyamide-imide resin (PAI), can be cured by heating, and therefore is preferred from the

viewpoint of the production.

And besides, by the addition of a known solid lubricant, such as graphite and molybdenum disulfide, to these resins, the friction coefficient can be improved.

The thickness of the resin layer should be 2 to 20 μm. If this thickness is less than 2 μm, the adequate initial conformability and anti-seizure property can not be obtained. In contrast, if the thickness of the resin layer is too large, the heat-radiating property is lowered. Therefore, in view of the balance between the two, this thickness should be 2 to 20 μm. 5 to 10 μm is particularly preferred.

According to a further feature of the present invention, if the Cu alloy layer and the Ag layer contain no Pb, the Pb free sliding member can be provided, and this sliding member is gentle to the environment.

As described above, in the invention of claim 1, the multi-layer sliding member comprises the backing metal, the Cu alloy layer formed on the backing metal, the Ag layer formed on the Cu alloy layer, and the resin layer formed on the Ag layer, the Ag layer having a thickness of 3 to 50 μm, and the resin layer having a thickness of 2 to 20μm. With this construction, the multi-layer sliding member has an excellent anti-seizure property.

In the invention of claim 2, the Ag layer can

be composed of pure silver or a silver alloy. If the Ag layer is composed of a sliver alloy, the wear resistance can be enhanced.

In the invention of claim 3, even if the Cu alloy layer and the Ag layer contain no Pb, there can be provided the multi-layer sliding member which makes less attack on a mating member, and is excellent in wear resistance.

In the invention of claim 4, the resin layer comprises a mixture of a thermosetting resin and a solid lubricant, and with this construction, there can be provided the multi-layer sliding member which makes less attack on a mating member, and is excellent in anti-seizure property.

In the invention of claim 5, a bearing comprises the milti-layer sliding member as defined in any one of claims 1 to 4, and this bearing exhibits an excellent anti-seizure property.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an enlarged, cross-sectional view of a portion of a multi-layer sliding member of the present invention;

Fig. 2 is an enlarged, cross-sectional view of a portion of a conventional multi-layer sliding member; and

Fig. 3 is an enlarged, cross-sectional view of a portion of another conventional multi-layer

sliding member.

DESCRIPTION OF THE INVENTION

Examples of the present invention as well as comparative examples will now be described.

In order to ascertain the effects of the present invention, test samples of Examples 1 to 8, shown in Fig. 1, and test samples of Comparative Examples 1 to 6 were prepared. First, a Cu alloy (Cu-11Sn-3Ni) layer 2 was formed by sintering on a backing metal 1, comprising a steel plate, and this intermediate product was rolled, and then was shaped into a bearing having a thickness of 1.5 mm. An Ag layer 3, comprising Ag or an Ag-Sb alloy, was formed on the Cu alloy layer 2 by wet electroplating using a cyanide bath. In this manner, the test samples, having the composition and thicknesses shown in Table 1, were prepared. Further, a resin layer 4 was formed on the Ag layer 3. The resin layer 4 was formed by a mixture of a thermosetting polyamide-imide (PAI) and molybdenum disulfide (MoS_2) serving as a solid lubricant. An organic solvent was added to this mixture, and the mixture was sprayed onto the Ag layer 3 by the use of an air spray to form a coating thereon. Then, this coating was heated and cured at 250°C for 30 minutes to form the resin layer 4.

In this manner, the test samples of the half bearings, having the composition and thicknesses shown

in Table 1, were prepared. In Examples 3 and 4 and Comparative Example 1, an epoxy resin was used as the resin.

Table 1

		Ag layer		Resin layer		Maximum specific load not causing seizure (Mpa)
		Material	Thickness (μm)	Material	Thickness (μm)	
Example	1	Ag	5	60%MoS_2-40%PAI	5	85 to 90
	2	Ag	5	70%MoS_2-30%PAI	10	85 to 95
	3	Ag	10	50%MoS_2-50%Epoxy	10	80 to 90
	4	Ag	5	70%MoS_2-30%Epoxy	15	85 to 90
	5	Ag	20	60%MoS_2-40%PAI	10	80 to 90
	6	Ag	35	65%MoS_2-35%PAI	5	85 to 90
	7	Ag-5%Sb	5	60%MoS_2-40%PAI	10	85 to 95
	8	Ag-5%Sb	15	50%MoS_2-50%PAI	5	85 to 90
Comparative Example	1	None	-	40%MoS_2-60%Epoxy	5	55 to 60
	2	None	-	60%MoS_2-40%PAI	10	60 to 65
	3	None	-	10%MoS_2-90%PAI	5	50 to 60
	4	Ag	1	50%MoS_2-50%PAI	5	50 to 60
	5	Ag	5	40%MoS_2-60%PAI	30	50 to 55
	6	Ag	10	70%MoS_2-30%PAI	1	55 to 60

Next, a seizure test was conducted. This test was carried out under the following conditions, and results thereof are shown in Table 2.

Table 2

Test conditions	Dimension	Unit
Diameter of shaft	ϕ53	mm
Width of bearing	13	mm
Number of revolutions	3600	rpm
Peripheral speed	10	m/s
Lubricating oil	SAE 20	-
Inlet temperature	98 to 102	°C
Oil feed pressure	12.5	cc/min
Shaft: Material	S55C	-
: Roughness	Not more than 1.0	Rmax μm

As will be appreciated from the results of this seizure test, Examples 1 to 8, having the construction of Fig. 1, exhibited the high anti-seizure property in the range of 80 to 95 Mpa. On the other hand, Comparative Example 4, having the Ag layer 3 with a thickness of 1μm, exhibited the low maximum seizure load on the order of 50 to 60 Mpa. Comparative Example 5, having the 5μm thick Ag layer 3 and the 30 μm thick resin layer 4, exhibited the low maximum seizure load of 50 to 55 Mpa, and Comparative Example 6, having the 10μm thick Ag layer and the 1 μm thick resin layer,

exhibited the low maximum seizure load of 55 to 60 Mpa. Comparative Examples 1 to 3, in which the resin layer 4 was formed directly on the Cu alloy layer 2 as shown in Fig. 3, were subjected to seizure at the specific load of 50 to 65 Mpa, and this indicates that the examples of the present invention, having the Ag layer 3, are excellent in anti-seizure property.

CLAIMS:

1. A multi-layer sliding member comprising a backing metal, a Cu alloy layer formed on said backing metal, an Ag layer formed on said Cu alloy layer, and a resin layer formed on said Ag layer, said Ag layer having a thickness of 3 to 50 μm, and said resin layer having a thickness of 2 to 20μm.

2. A multi-layer sliding member according to claim 1, in which said Ag layer is composed of pure silver or a silver alloy.

3. A multi-layer sliding member according to claims 1 or 2, in which said Cu alloy layer and said Ag layer contain no Pb.

4. A multi-layer sliding member according to any one of claims 1 to 3, in which said resin layer comprises a mixture of a resin and a solid lubricant.

5. A half bearing comprising a multi-layer sliding member as defined in any one of claims 1 to 4.

6. A multi-layer sliding member as shown in Fig. 1.

7. A half bearing comprising a multi-layer sliding member as shown in Fig. 1.

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Application No:	GB 9909597.8	**Examiner:**	John Hewet
Claims searched:	1 to 5	**Date of search:**	15 July 1999

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UK Cl (Ed.Q): F2A (AD38, AD44)

Int Cl (Ed.6): F16C 33/04, 33/20, 33/22

Other: EDOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2221502 A (DAIDO) see especially page 3 lines 13 to 22	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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